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METHOD AND APPARATUS FOR DRYING END POINT DETECTION OF DRY-CLEANING SOLVENT

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[There are no amendments to this patent.]

Claims

1. A method for the detection of the drying end point of a dry-cleaning solvent, characterized by using a semiconductor detection device and a heating means, wherein the voltage applied to the heating means is controlled to heat the semiconductor detection device to 440-500°C.

2. A method for the detection of the drying end point of a dry-cleaning solvent, characterized in that, in a dry-cleaning solvent drying end point detection apparatus provided with a gas sensor and a gas suction means for feeding gas to be detected to the gas sensor, the gas suction means is rotated at a low speed when idle and at a high speed during measurement.

3. An apparatus for the detection of the drying end point of a dry-cleaning solvent, characterized by being provided with a gas sensor and a gas suction means at one open end of a cylindrical main body, wherein the gas sensor is fixed toward the open part inside the cylindrical main body or the sensor is fixed on the inner wall of the cylindrical main body.

4. An apparatus for the detection of the drying end point of a dry-cleaning solvent, characterized by being provided with a gas sensor and a gas suction means toward the one open end of the cylindrical main body and a plurality of light-emitting means in a row outside the main body, with a number of the light-emitting means lighting according to the concentration of gas detected by the gas sensor, wherein the light-emitting means comprises a group of light-emitting means of three different colors and the light-emitting means which emit the same color are placed side by side.

5. An apparatus for the detection of the drying end point of a dry-cleaning solvent, characterized by being provided with a gas sensor and a gas suction means at one open end of a cylindrical main body, wherein a gas barrier is installed between the gas sensor and gas suction means and another part.

Detailed explanation of the invention

Industrial application field

The present invention concerns technology for measuring gas concentrations, more specifically concerns a technology which is effective when used in an apparatus for measuring the concentration of residual dry-cleaning solvent in fabric.

Prior art and its problems

Conventionally, the evaluation of the dried state of solvents remaining in dry-cleaned fabric is dependent upon the worker's sense of smell. Thus, to accurately determine the drying point, an excellent sense of smell and much experience are needed, and there are problems of variation in judgments by individuals.

In addition to the detergency, dry-cleaning solvents are required to have high safety, and as a result of pursuing such performance, odorless dry-cleaning solvents have also been developed.

Therefore, when such solvents are used, the human sense of smell and touch are very inadequate in determining the state of dryness by conventional methods, with the possibility of increased accidents of returning undried clothes. When worn, undried clothes may cause skin inflammation.

To overcome such problems, previously, the present inventors developed dry-cleaning solvent drying end point detection apparatus (Japanese Patent Application No. Sho 62[1987]-291427). By using this apparatus, determining the state of dryness of clothes, conventionally dependent on the worker's senses and experience, can be done by anyone. However, the drying end point detection apparatus described above is not sufficient in its responsiveness to the dry-cleaning solvent vapor, and it takes a long time to determine results from the beginning of the operation and for the display to return to the state before operation.

Furthermore, if the operation display circuit is exposed to gas, the circuit parts may deteriorate.

The present invention concerns an improvement of the previously applied invention described above, and it is an objective of the present invention to enhance the responsiveness to dry-cleaning solvent vapor and shorten the recycle time after determination, for improved effectiveness of drying end point detection work.

Means to solve the problems

To achieve such objectives, according to the present invention, in a method for detecting the drying end point of dry-cleaning solvent by the output voltage of a hot-wire type semiconductor gas sensor comprising a semiconductor detection device and a heating means, the voltage applied to the gas sensor heating means is controlled to a device temperature of 440-500°C.

Furthermore, with the open part of the gas sensor placed toward the one open end of the cylindrical main body, the gas sensor is easily contacted by gas.

To prevent gas from remaining around the gas sensor when idle, the fan used for bringing in the gas is run at a low speed.

Also, a partition wall is placed between the gas sensor and gas suction means and another part, to prevent exposure of the other part, especially a circuit part, to gas.

Operation

According to the means described above, the device is heated to 440-500°C, thus adsorption-desorption of gases of high molecular weight to the semiconductor detection device is promoted, enhancing responsiveness to vapor of dry-cleaning solvents such as kerosene, light oil, etc.

The gas is suctioned continuously, so gas detected in a previous operation is not likely to remain in the apparatus main body, resulting in a shortened recycle time.

Furthermore, with the partition wall, the circuit part is protected from the gas.

Application example

Figure 1 illustrates an example of a manual dry-cleaning solvent drying end point detection apparatus of the present invention.

In the drying end point detector of this example, as shown in the figure, a dust prevention part (2) having a stainless mesh is provided at one open end of the cylindrical main body (1). Behind the dust prevention part (2) inside the main body (1), a hot-wire type semiconductor gas sensor (3) is placed, and further behind, an 8-blade fan (4) and operating motor (5) are placed. By running the fan (4), air is brought in through the opening at the dust prevention part (2) with rapid detection by the gas sensor (3). For rapid discharge of the air brought in by the fan (4), an air discharge port (6) is formed at the top bent part of the main body (1).

Furthermore, a partition wall (16) is formed so that the air and gas brought in by the fan are not in contact with other parts, especially the circuit boards (11, 12).

On the board (3a) for mounting the gas sensor (3), at the forward position of the gas sensor, a thermistor (TH) is installed as a temperature sensor.

Furthermore, in Figure 1, the cylindrical part of the main body (1), illustrated with its bottom tilted to the right, has a grip part, and this grip part (1a) has a hand switch button (7) for starting the operating motor (5) for the fan (4), with a portion of the button exposed from the main body (1). The button (7) is elastic with its one end (lower end in the figure) fixed to the inner wall of the main body (1) and the other end (upper end in the figure) being free. A microswitch (8) facing the back of the button (7) is installed on the board (12).

On the other hand, at the upper end of the back of the grip (1a), a display part is installed by mounting transparent parts (9) to the main body (1), and against each transparent part (9), e.g., 12 light-emitting diodes LED_1 - LED_{12} are mounted on the board (11) that is fixed inside the main body (1). Such display part may be liquid crystal. Of these light-emitting diodes LED_1 - LED_{12}, LED_1 - LED_4 are for red emission, LED_5 - LED_8 for yellow emission, and LED_9 - LED_{12} for green emission.

On the board (11) and the board (12) parallel to each other, a dry detection circuit and its power source circuit (neither shown in the figure) are installed for controlling the light-emitting diode displays LED_1 - LED_{12}, the gas sensor (3) and the fan operating motor (5).

Figure 1 also shows a transformer (13) constituting the power source circuit and insertion hole (15) for the power cord (14).

In this example, as shown in Figure 3(A), in the sensor (3), two pairs of electrode pins (32, 33) penetrate through the ceramic board (31), and a detection device (34) of SnO_2 is connected between one pair of electrode pins, and a heater (not shown in the figure) between another pair of electrode pins. A stainless steel cover (35) is installed over the detection device (34), and the cover (35) comprises a retainer frame (35a), provided to the outer end of the ceramic board (31), and a semispherical mesh part (35b).

When-the gas sensor is provided inside the apparatus of Figure 1, for a smooth gas flow, it is necessary to make the mounting board (3a) parallel to the direction of flow. However, in this case, with a sensor having a structure as shown in Figure 3(B), because the suctioned gas flows parallel to the device, it is difficult for the gas to enter through the mesh (35b), thus the amount of gas to be contacted with the device will be small. On the other hand, with a sensor having a semispherical mesh (35b) as shown in Figure 3(A), even with the mounting board (3a) parallel to the flow, a sufficient amount of suctioned gas flows into the mesh and contacts the device (34), resulting in an improved sensitivity. In the case of using a sensor with the structure of Figure 3(B), as shown in Figure 7, by facing the gas sensor opening part to the main body opening part, the amount of gas contacting the device can be increased for increased sensitivity.

Furthermore, since a semiconductor gas sensor is used, the sensitivity is good with excellent reliability and durability, and an accurate drying end point can be obtained even for odorless solvents. Also, since the automatic fan suction method is used, responsiveness is excellent. Furthermore, e.g., since the dry state is displayed in 12 stages in three colors of red, yellow and green, the drying end point can be determined accurately even by workers with no experience and no sensitive sense of smell.

In this example, the fan is placed behind the gas sensor. However, the fan may be placed in front of the gas sensor.

Figure 2 illustrates an example of a gas concentration detection circuit that is a part of the detection control device embedded inside the main body of the drying end point detection apparatus described above.

In this figure, using a hot-wire type semiconductor gas sensor (GS), the heater (HT) inside the sensor is powered simultaneously with power source to heat the device. When heated, the SnO_2 crystal in the device acts as an n-type semiconductor, and the resistance between the terminals A-B changes according to the surrounding gas composition.

In this example, the transistor (TR) for applying operating voltage to the sensor (GS) is connected between the power source voltage (Vcc) and one terminal (A) of the sensor (GS), and a variable resistance (VR) for compensating the variation of resistance value of the sensor (GS) is connected between the other end (B) of the sensor (GS) and ground.

Furthermore, at the base terminal side of the transistor (TR) described above, a temperature compensation circuit (TC) comprising resistors (R_1, R_2, R_3) and thermistor (TH) is installed. The resistors (R_1, R_2, R_3) are connected in series between the power source voltage (Vcc) and ground (GND), and of these, the resistor (R_3) is connected to the thermistor (TH) in parallel. Therefore, the ground node n_1* voltage of the resistors (R_1) and (R_2), i.e., a voltage obtained by dividing the power source voltage (Vcc) by the ratio of the resistance R_4 to the combined resistance of R_1, R_2, R_3 and thermistor (TH), is applied to the base terminal of the transistor (TR). By means of the resistors R_1, R_2 and R_3, the thermistor temperature characteristics and the gas sensor (GS) temperature characteristics are matched, the thermistor (TH) resistance value, varying according to the surrounding temperature, is converted into a voltage, and the power source voltage (Vcc') (= Vn_1 - V_{BE}) applied to the gas sensor (GS) is varied according to the surrounding temperature to carry out the temperature compensation of the gas sensor (GS).

In the above description, Vn_1 is the voltage of node n_1 and V_{BE} is the voltage between the base emitters of the transistor (TR) and is about 0.7 V.

The resistor (R_4) connected between the node n_1 of the temperature compensation circuit (TC) and the base terminal of the transistor (TR) stabilizes the impedance of the transistor (TR) viewed from the node n_1. On the other hand, the transistor (TR) acts as a buffer to keep the applied voltage constant even when the gas sensor (GS) resistance varies according to the temperature.

The resistance value of the gas sensor (GS) also changes according to the type of gas to be detected. However, even in this case, the relationship between the gas concentration and the resistance value is the same, and on the graph, lines representing each characteristic appear parallel to each other. Accordingly, when different types of gases are detected, by controlling the resistance value (R_v) of the variable resistor (VR), the level of output (V_{out}) can be matched to the detection concentration.

In this application example, the voltage V_H applied to heater HT is controlled such that the element is heated to 440-500°C.

Furthermore, in this example, for gas sensors using SnO_2 as the detection device, the voltage (V_H) applied to the heater and the temperature of the device heated by this heater have

* [Editor's note: Subscripted numbers are barely legible in the original document; best guesses have been given.]

the relationship shown in Figure 5, and the temperature increases with increasing applied voltage (V_H). However, the relationship between the voltage (V_H) applied to the heater and the return time (t_R) of the sensor output voltage to the atmospheric level is such that, e.g., in the case of n-undecane ($C_{11}H_{24}$) as the gas to be detected, as shown in Figure 6, the return time (t_R) decreases with increasing voltage (V_H) applied to heater. Also, the response time is decrease in relation to the return time and is about ½ of the return time. This indicates that with increasing device temperature, adsorption-desorption of gases with high molecular weight on the device surface is accelerated. However, above 500°C, changes occur in the SnO_2 structure with deterioration of device characteristics and greatly reduced device lifetime. Therefore, in this example, the voltage (V_H) applied to the heater is limited to 6-6.8 V for improved responsiveness of the gas sensor.

Figure 4 shows an example of the gas concentration detection circuit described above, which is adapted into a determination control device embedded in the dry-cleaning solvent drying end point detector.

In this figure, the gas detection circuit has the symbol 21, which is the circuit shown in Figure 2. Power source voltage (Vcc) with alternating current converted to direct current at the power source circuit (20) via the hand switch contact point (S_1) is fed to the gas concentration detection circuit (21). By means of the transistor (Q_1), power is fed to the fast operating motor (5) installed inside the main body (1) of Figure 1, and the fan (4) runs at a low speed when idle, and when the hand switch is turned on, the current of the transistor (Q_1) increases, resulting in increased fan speed. To the heater (HT) of the gas sensor (GS) inside the gas concentration detection circuit (21), with power source input via the protection circuit comprising the resistor ($R_{[illegible]}$) and zener diodes (ZD_1, ZD_2), an alternating current of +6 V is supplied at the same time to heat to 440-500°C.

In the example of Figure 4, the output voltage (Vout) of the gas concentration detection circuit (21) is applied to the A/D conversion capability-embedded LED driver (LDR), and the LED driver (LDR) determines where the detected gas concentration belongs in the 12 levels and operates the LED array (L-ARY) containing the row of 12 light-emitting diodes. The LED array (L-ARY) lights more LEDs with increasing gas concentration as an analog display of the detected gas concentration.

With concentrations displayed in three colors according to the detection level, the light-emitting diodes light from green to red at high concentration and yellow to green or green alone at low concentration, making the determination by workers easy.

With the circuits of this example, after input of the power source, it takes more than a minute until the temperature of the heater (HT) of the gas sensor (GS) rises to a desired value and the sensor detection capability is stabilized. To compensate for this unstable period, a CR time constant type timer circuit (TM_1) is installed. With this timer circuit (TM_1), after a power

source is input, a high level of wait signal (tw) is output for about 2 min, and this signal is fed to the base of the transistor (Q_2) that can operate the light-emitting diodes (LED_1 - LED_{12}). With this, upon power input, a first current flows into the transistor (Q_2), and all light-emitting diodes (LED_1 - LED_{12}) are lit for 2 min. Then, with the transistor (Q_2) off, the light-emitting diodes (LED_1 - LED_{12}) are turned off, with only the green light-emitting diode (LED_{12}) remaining lit.

In this example, the power source input is announced by an audible sound by installation of the timer circuit (TM_2), oscillator circuit (29) and buzzer (30). The timer circuit (TM_2) is the same type of CR time constant type circuit as the timer circuit (TM_1), with internal resistance and capacitance values set to output a high level signal for about 0.2 sec. The output signal of this timer circuit (TM_2) is supplied via the NOR gate (G_1) to the oscillation circuit (29) to output an oscillation signal for 0.2 sec to sound the buzzer (30).

In this example, to sound the buzzer when all of the light-emitting diodes (LED_1 - LED_{12}) are lit upon the power source input, then only one green light lights 2 minutes later, and when the hand switch is turned on, trigger pulse generation circuit (27) and mono-stable multivibrator (28) are actuated. Two signals, i.e., a signal obtained by inversion of the timer (TM_1) output by the inverter (INV) and also the signal from the contact point (S_1), are input to the trigger pulse generation circuit (27). The trigger pulse generation circuit (27) detects the rising edge of these signals from low level to high level and generates a whisker-shaped trigger pulse (TP) when any signal rises. This trigger pulse (TP) activates the mono-stable multivibrator (28), expanding the pulse width to form, e.g., a pulse of 0.1 sec width. This pulse is supplied to the oscillation circuit (29) via the NOR gate (G_1) for 0.1 sec to sound the buzzer (30).

Effects of the invention

As explained above, according to the present invention, in a method for detecting the drying end point of a dry-cleaning solvent using a hot-wire type semiconductor gas sensor comprising a semiconductor detection device and a heating means and determining the end point by the level of sensor output voltage, the device is operated at 440-500°C by control of the voltage applied to the heating means of the gas sensor, with accelerated adsorption-desorption of high-molecular-weight gas to the gas sensor, resulting in enhanced responsiveness to dry-cleaning solvent vapors such as kerosene, light oil, etc.

Installation of the gas sensor toward the one open end of the cylindrical main body facilitates the contact of gas to the sensor, with improved sensitivity.

With the fan for gas intake running at a low speed when idle, no gas will remain from the previous operation, resulting in a shortened return time.

As a result, the efficiency of determining the drying end point of dry-cleaning solvent is greatly increased.

Furthermore, the gas sensor and gas intake means are separated from other parts by a barrier wall for protection of circuit parts from gases, resulting in improved reliability.

Brief description of the figures

Figure 1 is a cross-sectional diagram illustrating an example of the dry-cleaning solvent drying end point detector of the present invention (an example using a gas sensor having the structure of Figure 3(A)).

Figure 2 is a circuit diagram illustrating an example of gas concentration detection circuit suitable for use in the above drying end point detector.

Figure 3(A) is a cross-sectional diagram illustrating a constitutional example of the gas sensor used in the dry-cleaning solvent drying end point detector of the present invention.

Figure 3(B) is a cross-sectional diagram illustrating another constitutional example of the gas sensor used in the dry-cleaning solvent drying end point detector of the present invention.

Figure 4 is a circuit diagram illustrating an example of the determination control circuit used in the above gas concentration detection circuit.

Figure 5 is a graph illustrating the relationship between the voltage applied to the heater of the gas sensor and the device temperature.

Figure 6 is a graph illustrating the relationship between the voltage applied to the heater of the gas sensor and the time needed for return of the output voltage.

Figure 7 is a cross-sectional diagram illustrating an example of the dry-cleaning solvent drying end point detector of the present invention using the gas sensor of Figure 3(B).

1	Apparatus main body
1a	Grip
2	Dust prevention part
3	Gas sensor
35	Sensor cover
35a	Mesh part
4	Gas intake means (fan)
5	Fan motor
6	Air exhaust
7	Hand switch operating button
8	Microswitch
9	Display part
13	Transformer
GS	Gas sensor
LED_1 - LED_{12}	Light-emitting diodes